B500

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LOGARITHMIC LCR BRIDGE

OPERATING INSTRUCTIONS

WAYNE KERR

MP MASTER
MA24500

OPERATING INSTRUCTIONS

for

LOGARITHMIC LCR BRIDGE

B500

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CONTENTS

	Page
INTRODUCTION	7
OPERATING INSTRUCTIONS	8
CONTROLS	8
MEASUREMENT PROCEDURES	9
Preliminary	9
Switching On	9
Connections	10
Measurements—Range Known	10
(a) Two Terminal Measurement—Ranges 4–10	10
(b) Three Terminal Measurement—Ranges 4–10	11
(c) Four Terminal Measurement—Ranges 1–3	12
Measurements—Range Not Known	12
Measurements—2x Line Frequency	13
Measurement of Electrolytic Capacitors—Ranges 1–3	13
Measurement of Iron Cored Inductors carrying d.c.—Ranges 4–10	14
Measurement of Mutual Inductance—Ranges 1–3	15
Measurement of Potentiometer Linearity	16
INTERPRETATION OF RESULTS	16
Lossy Components	16
Correction Curves	17
Shunt Loading	17
Graph 1 R corrections—Ranges 1–3	17
SPECIFICATION	18

ILLUSTRATIONS

		Page
Fig. 1	Two Terminal Measurements	10
Fig. 2	Three Terminal Measurements	11
Fig. 3	Three Terminal Measurements (High Impedance)	11
Fig. 4	Four Terminal Measurements	12
Fig. 5	Measurement of Electrolytic Capacitors—Ranges 1–3	13
Fig. 6	Measurement of Iron Cored Inductors carrying d.c.—Ranges 4–10	14
Fig. 7	Measurement of Mutual Inductance—Ranges 1–3	15
Fig. 8	Potentiometer Linearity Measurements	16

WAYNE KERR
Logarithmic LCR Bridge B500
Subtract T
10%
10%
Phase Angle
L C R
μH | μH x 10 | μH x 100 | mH | mH x 10 | mH x 100 | H | H x 10 | H x 100 | kH
mF | μF x 100 | μF x 10 | μF | nF x 100 | nF x 10 | nF | pF x 100 | pF x 10 | pF
mΩ x 10 | mΩ x 100 | Ω | Ω x 10 | Ω x 100 | kΩ | kΩ x 10 | kΩ x 100 | MΩ | MΩ x 10
L C R
On
Supply
Frequency 2x Line
1000 Hz
Sensitivity
Search

INTRODUCTION

The B500 Bridge is of the transformer ratio arm type for the measurement of inductance, capacitance and resistance. Balance is obtained using an accurately wound slide wire, suitably shunted to provide the logarithmic scale, in conjunction with a continuously variable control for phase angle, and a ten position range switch.

Measurements of inductance, capacitance and resistance are made at 1kHz—derived from a stable Wien Bridge Oscillator. In the case of inductors and capacitors, a facility is provided to measure these at twice line frequency.

Measurements may be of the two, three or four terminal type, the second being used for components in situ, *the latter for components whose impedance is less than* 10 *ohms. An extremely useful facility is provided for rapid range determination in instances where the value of the component is unknown.*

The instrument may be used with either 50 *or* 60*Hz;* 200–250*V*/100–125*V or with an external* 9–12*V d.c. supply.*

OPERATING INSTRUCTIONS

CONTROLS

Logarithmic Scale Control

This gives, in conjunction with the Range and Function switches, the value of the major term when the bridge is at balance.

Phase Angle

This is a continuously variable control calibrated from 0–45° with 5° subdivisions. In conjunction with the Logarithmic Scale Control, it enables the operator to calculate the quality of the component.

Range Switch

This ten-position switch provides the necessary multiplying factors for the Logarithmic Scale Control.

Function Switch LCR

This is set to suit the major term of the component under test, depending on whether it is inductive, capacitive or resistive.

Supply Switch

At the lower left hand side of the instrument is the supply switch; the bridge is operational when this switch is in the up, On position.

Frequency Switch—2 x Line/1000Hz

This two-position switch determines the operating frequency of the bridge.

In the 2x Line position, the bridge should only be used for the measurement of large capacitors and inductors. This facility is not available when the bridge is operated from an external d.c. supply.

Sensitivity

A continuously variable control for adjusting the gain of the detector.

'Subtract 1' Button

This is a spring-loaded push button, which extends the range of the logarithmic slide wire control, so that measurements can be made between 0 and 1. This facility is available on Range 1, for resistive and inductive measurements, and on Range 10 for capacitive measurements.

Search Button

This is a spring-loaded push button enabling the meter to be used for rapid range determination.

Pre-set Controls

Two pre-set controls are contained within the instrument; one to set the 1000Hz oscillator frequency, the other to set the detector gain. The settings of these controls are carefully adjusted during manufacture and do not normally require further adjustment. Neither of these controls should be adjusted except as detailed in the Maintenance Manual.

MEASUREMENT PROCEDURES

PRELIMINARY

Ensure that the voltage selector is set to the correct voltage tapping. To do this, place the instrument face down on the bench and give the 4 Camloc fasteners in the rear cover a quarter turn counter-clockwise. The rear cover can then be withdrawn. Should difficulty be experienced in removing this cover, slacken the three nylon screws in one of the side plates. The cover can then easily be removed. The two-position voltage selector slide switch is mounted on the chassis to the right of the null indicator meter with the meter nearest to the operator. Remove the switch locking plate and slide the switch in the direction suiting the supply; 100–125V or 200–250V. Replace the instrument rear cover, give each fastener a quarter turn clockwise and tighten the nylon screws.

SWITCHING ON

The instrument is supplied with a three-wire connecting lead for the a.c. supply, terminated with a three-pin free socket at one end. This should be inserted into the input plug on the left-hand side of the instrument. The free end of the lead should be fitted with a suitable three-pin plug: red to live, black to neutral and green to earth.

For operation from a d.c. supply, two sockets are provided—one red and one black. These are adjacent to the input plug and are engraved 9–12V d.c. Should the supply become accidentally reversed, the instrument will be inoperative

although no damage will result because a protective circuit is included. Apart from protecting against reversed polarity, the circuit prevents current flowing from the internal power supply into the external d.c. supply, and vice versa. This means that it is possible to operate the instrument with both a.c. and d.c. supplies connected simultaneously.

The supply switch breaks both the a.c. and d.c. power supplies, so that if required both supplies may be left connected.

The instrument requires no warm up period, the specified accuracy being obtained immediately after switching on.

CONNECTIONS

Connection of the component under test is made either directly, or via leads, to the terminals on the front panel. Measurements may be of the two, three or four terminal type. For certain low capacitance measurements on Range 10, it will be necessary to screen the I terminals from the E terminals and a special plate is provided for this purpose. This simply clamps under the N_I terminal.

MEASUREMENTS–RANGE KNOWN

(a) Two Terminal Measurements—Ranges 4–10

Ensure that the terminals N_E and N_I are linked.

Connect the component between terminals E and I —see Fig. 1.

Set Function switch to appropriate position—L, C or R.

Set Range switch to correct range.

Set Sensitivity control to minimum (i.e. fully counter-clockwise).

Adjust cursor and Phase Angle control until meter gives null reading. If insufficient sensitivity is obtained, increase by rotating the control in a clockwise direction.

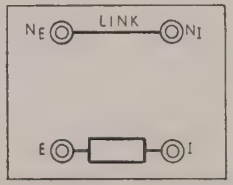


Fig. 1. Two Terminal Measurements.

The value of the component is the cursor reading multiplied by the appropriate factor from the Range switch scale.

To measure low values of capacitance between 0 and 1pF on Range 10, press the Subtract 1 button and balance the bridge as described above.

N.B.—When the Subtract 1 button is depressed, the value of the component is obtained by subtracting one from the cursor reading. Under these conditions the screening plate must be used as described in CONNECTIONS, page 10. (The screening plate may be needed over the whole of Range 10.)

(b) Three Terminal Measurements—Ranges 4–10

This method is used to measure *in situ* components.

Ensure that the terminals N_E and N_I are linked.

Connect the component (A) to be measured as shown in Fig. 2.

The effects of shunt impedances B and C are then removed. Where high impedances are involved stray capacitances could invalidate the measurement, and the connections must then be made as shown in Fig. 3, using screened leads.

Measurements are then made in accordance with paragraph (a), page 10.

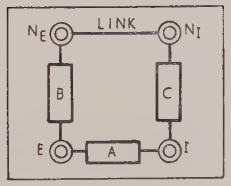


Fig. 2. Three Terminal Measurements.

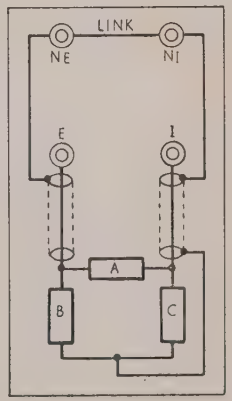


Fig. 3. Three Terminal Measurements (High impedance)

(c) Four Terminal Measurements—Ranges 1–3

This method is used to measure a component of low impedance.

Remove the link between terminals N_E and N_I.

Connect component as in Fig. 4.

Attempt balance on Range 3 as described in paragraph (a).

If this is not possible, select Range 2 or Range 1.

When using Range 1 for measuring resistance or inductance it may be found that balance is indicated below 1μH or 10mΩ. In this instance the range may be extended to 0 by the use of the Subtract 1 button. The true value is obtained by subtracting 1μH (if L) or 10mΩ (if R) from the indicated reading.

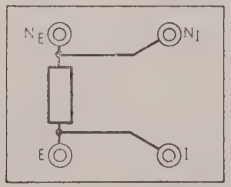


Fig. 4. Four Terminal Measurements.

MEASUREMENTS–RANGE NOT KNOWN

Ensure that terminals N_E and N_I are linked.

Connect component between terminals E and I—see Fig. 1.

Set Function switch to appropriate position—L, C or R.

Set Range switch to position 4.

Press the Search Button.

(If the meter reading is to the right of the green band on Range 4, this indicates that the component is of low impedance, and should be measured using the procedure in paragraph (c), page 12.)

If the meter reads within the green band, release the Search Button and adjust the cursor and Phase Angle controls for final balance as described in paragraph (a), page 10.

Should the meter read to the left of the green band with the Search Button pressed, rotate the Range switch until the meter reads in this band.

Release the Search Button.

Adjust the cursor and Phase Angle controls for final balance as described in paragraph (a) page 10.

N.B.—If the type of component to be measured is not known, it will be necessary to make a trial balance in all three positions of the Function switch.

MEASUREMENTS—2x LINE FREQUENCY

These apply only to measurements of large capacitors (Ranges 1–3) or large inductors (Ranges 6–10). For the former, four terminal measurement is required (Fig. 4), and for the latter, two terminal measurement (Fig. 1). Set the Frequency switch to 2x Line and proceed as described in paragraph (a) or (c) as appropriate, page 10 or 12.

This facility gives an improvement of approximately 100 : 1 in the ratio of stray impedance to required impedance and is of considerable value in reducing the effects of series inductance of large capacitors and self capacitance of large inductors. It also provides measurements of these components at a frequency nearer to that at which they are likely to be used.

N.B.—The Search Button facility and Phase Angle calibration apply only at 1000Hz. The search facility cannot therefore be used for rapid range determination at 2x line frequency.

The 2x Line signal is available only when the instrument is operated from a 50–60Hz supply.

MEASUREMENT OF ELECTROLYTIC CAPACITORS—RANGES 1–3

In practice it has been found that measurements of electrolytic capacitors may be made without using a polarising voltage. In the majority of cases, the impedance of the component under test will require a four terminal measurement. Should it be desired to use a polarising voltage, the connections to the bridge should be made as in Fig. 5 and the measurement made in the normal manner. The source of d.c. employed must not exceed an e.m.f. of 5V.

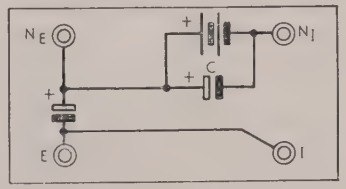


Fig. 5. Measurement of Electrolytic Capacitors—Ranges 1–3 (Table 1).

A capacitor is required to by-pass the series impedance of the polarising supply. The value of this is given in Table 1. With the value of C specified, a further error of up to 1% will be introduced to the measured value, which may be reduced if required by substantially increasing the value of C; this, of course, may not be practicable. Alternatively, a stabilised supply with an output impedance of less than 1 ohm may be used.

Range	Value of C (1000Hz)	Value of C (2x LINE FREQUENCY)
1	200μF	2000μF
2	100μF	1000μF
3	50μF	500μF

Table 1. Value of Capacitor for circuit of Fig. 5.

MEASUREMENT OF IRON CORED INDUCTORS CARRYING D.C. RANGES 4–10

Set the Frequency switch to the desired position. (In the case of 2x Line Frequency being required, the instrument must be operated from a suitable 50–60Hz supply.)

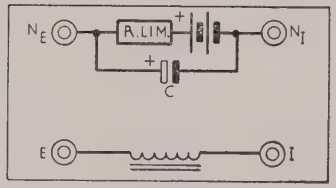


Fig. 6. Measurement of Iron Cored Inductors carrying d.c. —Ranges 4–10 (Tables 2 and 3).

Range	Value of C (1000Hz)	Value of C (2x LINE FREQUENCY)
4	1000μF	10,000μF
5	100μF	1,000μF
6	10μF	100μF
7	1μF	10μF
8	100nF	1μF
9	10nF	100nF
10	1nF	10nF

Table 2. Value of Capacitor for circuit of Fig. 6.

Connect the component under test as shown in Fig. 6. The limiting resistor R must be calculated so that the current flowing does not exceed the value given for each range in Table 3. Alternatively,

Range	Maximum D.C.
4	1 Amp
5	500 mA
6	500 mA
7	50 mA
8	50 mA
9	5 mA
10	5 mA

Table 3. Maximum Direct Current in circuit of Fig. 6.

a current limited source may be employed.
The value of C may be found from Table 2.

With the value of C specified, a further error of up to 1% will be introduced to the measured value, which may be reduced if required, by substantially increasing the value of C; this, of course, may not be practicable.

MEASUREMENT OF MUTUAL INDUCTANCE—RANGES 1–3

Ensure that terminals N_E and N_I are linked.
Connect component as shown in Fig. 7.

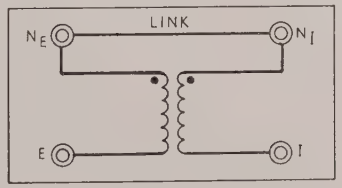


Fig. 7. Measurement of Mutual Inductance—Ranges 1–3.

Set Function switch to L.
Set Range switch to required range.

Balance as described in paragraph (a), page 10. The value of inductance read off is, in fact, the mutual inductance.

N.B.—The phase of the windings must be correct as shown in Fig. 7.

MEASUREMENT OF POTENTIOMETER LINEARITY

Ensure that terminals N_E and N_I are linked.
Set Function switch to R.
Select values for R and RV in Fig. 8 of total value at least 25 times the value of the potentiometer to be measured.
Set the Range switch to a position that would produce balance near the low end of the cursor scale, if R and RV were connected in series across the E and I terminals, and a two terminal measurement were being undertaken. (Assuming RV at maximum resistance.)
Connect the circuit as shown in Fig. 8.
Adjust the potentiometer to be measured so that the wiper is in contact with the end connected to the E terminal.
Adjust RV to produce balance at 1 on the cursor scale.

The potentiometer to be measured is then rotated, and the instrument re-balanced. The bridge readings are of Rx(1/ratio) of the potentiometer and can be tabulated against angle of rotation.

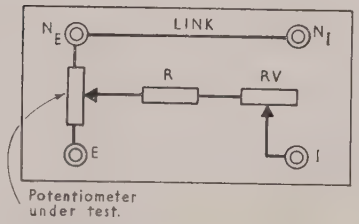


Fig. 8. Potentiometer Linearity Measurements.

INTERPRETATION OF RESULTS

LOSSY COMPONENTS

When making measurements of lossy inductors or capacitors, the results may be evaluated on a good bad basis by noting the setting of the Phase Angle control.

More accurate assessments can be made using mathematical tables, and the following expressions:

For capacitors $D = \tan \theta$

For inductors $Q = \cot \theta$

where θ is given directly by the Phase Angle control.

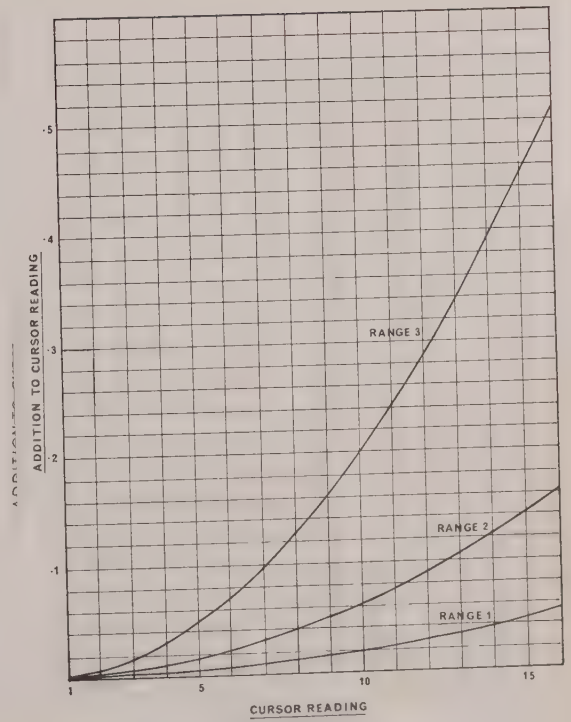
N.B.—The specification of the Phase Angle control should be considered when making the above measurements.

CORRECTION CURVES

When making measurements of low values of resistance on Ranges 1–3, the results must be corrected to obtain the specified 1% accuracy. The corrections given in Graph 1 should be added to the cursor reading obtained.

SHUNT LOADING

On Ranges 4–10, errors can be introduced due to shunt loading. The effects are not normally significant since a shunt load of up to ten times the measured capacitance value (one tenth the measured resistance or inductance value) produces less than 1% error, except on Range 4 where the heaviest shunt load for 1% error is equivalent to an impedance of 4 Ω.



Graph 1 Resistance Correction Ranges 1–3

SPECIFICATION

Overall Ranges

L	10nH – 16kH
C	10fF – 16mF
R	100μΩ – 160MΩ

1kHz Performance

RANGE	L			C			R			TEST SIGNAL
	SPAN	RES'LN	ACC'Y	SPAN	RES'LN	ACC'CY§	SPAN	RES'LN	ACC'CY	
1*	0–1μH	10nH	20nH	—	—	—	0–10mΩ	100μΩ	200μΩ	65mA p–p
1	1–16μH	10nH	1%	1–16mF	10μF	1%	10–160mΩ	100μΩ	1%	65mA p–p
2	10–160μH	100nH	1%	100–1600μF	1μF	1%	100–1600mΩ	1mΩ	1%‡	20mA p–p
3	100–1600μH	1μH	1%	10–160μF	100nF	1%	1–16Ω	10mΩ	1%‡	6.5mA p-p
4	1–16mH	10μH	1%	1–16μF	10nF	1%	10–160Ω	100mΩ	1%	65mV p–p
5	10–160mH	100μH	1%	100–1600nF	1nF	1%	100–1600Ω	1Ω	1%	650mV p–p
6	100–1600mH	1mH	1%	10–160nF	100pF	1%	1–16kΩ	10Ω	1%	650mV p–p
7	1–16H	10mH	1%	1–16nF	10pF	1%	10–160kΩ	100Ω	1%	6.5V p–p
8	10–160H	100mH	1%	100–1600pF	1pF	1%	100–1600kΩ	1kΩ	1%	6.5V p–p
9	100–1600H	1H	1%	10–160pF	100fF	1%	1–16MΩ	10kΩ	1%	65V p–p
10	1–16kH	10H	1%	1–16pF	10fF	1%	10–160MΩ	100kΩ	1%	65V p–p
10*	—	—	—	0–1pF	10fF	20fF	—	—	—	65V p–p

Ranges 1, 2 and 3 are four-terminal

Ranges 4–10 are two or three terminal

* 'Subtract 1' in operation

‡ After correction

§ C Standard t.c. =-200p.p.m/°C

Phase Angle

Calibrated only for 1kHz measurements
Reads 0–45 degrees
Balances shunt losses of capacitors and inductors, shunt capacitance of resistors, on Ranges 4–10
Balances series inductance of resistors on Ranges 1–3
Accuracy: ±5% of reading, ±1°

Ranges at 2x line frequency

L 1mH–16kH
C 10μF–16mF

Accuracy at 2x line frequency

As for 1kHz (see Table) but resolution is reduced.

Test Signal at 2x line frequency

RANGE	1	2	3	4	5&6	7&8	9&10
p–p	40mA	13mA	4mA	40mV	400mV	4V	40V

Frequencies

1kHz±2% (internal)
2x line (i.e. 100 or 120Hz). Selected by front-panel switch

Power Requirement

100–125v or 200–250V, 20VA, 50–60Hz
Or 9–12V d.c. at 50mA

Dimensions

Width 37 cm (14.5 in)
Height 21 cm (8.5 in)
Depth 13 cm (5 in)

Weight

Approx. 6 kg. (13 lb.)

MP MASTER

MA24500

THE WAYNE KERR COMPANY LIMITED

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